Exemplary Performance Of Chemical Recovery Unit At Satpuda Paper Mills

* Patil P.R., Jadhav, D.L., Singh S.N.
** Panduranga A., Venkateshwarlu J., Venu Bahadur Reddy B.

The Chemical Recovery unit was started in **November 1993** and is in operation since then. This has withstood the test of time. Based on the field performance it is acknowledged as one of the best Recovery units available in India for mini pulp mills using bagasse as the raw material.

The raw material for the additional requirement of paper has to come primarily from the agricultural residues. The major hurdle hitherto in using the agro based raw material was the absence of technically feasible & commercially viable Chemical Recovery unit.

Forty-two month of CRS operations at **SATPUDA PAPER MILLS** and mills allowing the interested parties to see the unit in operation has cleared, many of the doubts and the reservations with regards to the establishment of mini Chemical Recovery units for Bagasse pulp.

The success of CRS unit at Satpuda is on account of the Joint efforts by **SATPUDA PAPER MILLS & TMT (INDIA) LTD.**

The decision to have a Chemical Recovery unit was taken in the year 1990 by the **SATPUDA PAPER MILLS' team** under the **able and dynamic leadership** of their chairman **Shri Anna Sahib, P.K. Patil.** At the time of taking the decision for **CRS,** there was no small sized Chemical Recovery unit operating exclusively for the Black Liquor from Bagasse based pulp mill working on Soda process. M/s. **Mandya National Paper Mills** were using a **roaster** since decades and they wanted to have a full fledged Recovery unit and installed a **100 tpd DBLS** capacity unit, but this could not be operated due to various problems faced during commissioning. At this juncture to take a bold decision to have a Recovery unit for a (small) capacity of **65 tpd DBLS** is laudable. Being a visionary, he pursued the dreams to have an ideal sugar complex of large capacity based on modern technology. He organised to have the ancillaries and the auxiliaries such as the **Distillery unit, Sulfa unit, dry Ice plant, Biomethane unit, Particle board unit, etc. Not with standing,** he wanted to have a pulp and paper unit and decided to have one along with the Chemical Recovery System. Many people felt it as a **fantasy.** However he also being **pragmatic,** took the advice of M/s **Kraften Lagen (KAH), W-Germany, employed DCPL for project planning** and also discussed at length with various **consultants & suppliers from India and abroad;** he **employed highly experienced & talented personnel** to look after the project and took a **prudent** decision in selecting the **supplier** and **actively involved himself** at every stage of the project and **went out of way** in finding result oriented **solutions** whenever the project progress was **hindered.**

TMT (India) Ltd., on their part approached the problem devotedly. TMT was having **highly experienced** and **eminent** engineers exposed to the **design, manufacture** and **operation** of CRS units. They **pooled** all the information available with them and **evolved an appropriate and logistic design incorporating solutions to all the known problems** in the fields of operation, maintenance and safety. They got these schemes & designs **scrutinized** by various **experts in India and abroad** and finally **engineered** the unit **incorporating** all the valuable suggestions. No efforts were spared during the manufacture and the implementation stage. Even after commissioning the unit, their engineers **stayed for considerable time at the site to carryout further**

* SATPUDA PULP & PAPER MILLS
&
**TMT (India) Ltd.
S.R.P.M. Site, Govindapala
KURNOOL-581 004 (A.P.)

improvements. The net result is **a smooth operating, See-to-Believe Chemical Recovery unit,** which is not only **technically feasible** but also **economically viable and operator friendly.**

During the last 42 month's of operation, **various consultants, experts, executives** from the **Financial Institutions, Operating persons & chief Executives** of various Paper mills from India visited the unit. Some **experts** from **abroad** also visited the plant. **Many articles** were presented and discussed at length in various seminars & workshops, Refere to **(1), (2), (3), (4), (5), (6), (7) & (8)** given at the end.

In the present article, **the startup problems** encountered and the **yearly abstracts for 1995-1997** are included, as per the specific request of IPPTA.

During the 42 months operation the CRS unit at **Satpuda** was found to be **stable even at partial loads without the need of the auxiliary fuel support.** The **ledge formation** in the furnace and the **chemical deposits** in the boiler passes, which are the **common features** with any Recovery Boiler were **totally absent.** The **soot blowers,** though provided, were **not operated** (of late, once a shift in 15 days, the furnace soot blowers only are operated); the **unit is not shut for the internal cleaning** of the Boiler passes; **blackening** and **smelting** of the primary air ports, **spout jamming** problems **were not experienced; Autogenous combustion** was existing even when the firing concentration is maintained low **at 51° TW to 54° TW;** the **steam generation** is good; **Chemical Recovery** is good; **the input power and steam consumption's for the operation of the plant are very low;** above all the unit was found to be **operator friendly** and could be operated **safely** by the **local hands without any sacrificing efficiency.**

BRIEF DATA GIVEN FOR THE DESIGN OF SATPUDA CRS:

1	Raw Material		Bagasse
2	Bleached Pulp Capacity	t/Day	50
3	Dry Black Liquor Solids	t/Day	65
4	Black Liquor Solids Per Tonne Of the Bleached Pulp		1.3
5	Silica In Black Liquor Solids	%	1.2
6	Inlet Concentration of Black Liquor to the Evaporators	% DS	9
7	Final Concentration from the Evaporators	%	45
8	No. Of Effects in the Evaporators section	Nos.	4 + 1 (1 No. As Standby)
9	Calorific Value of the Black Liquor	Kcal/Kg	8,100
10	Boiler Operating Pressure	Kgs/Cm^2 (g)	12
	- Degree Of Superheat		Saturated
11	Recovered Caustic from the CRS	t/Day	13
12	Lime Purity For the Causticizers	% of CaO Available	60

BRIEF DATA OF THE CRS PLANT SUPPLIED TO M/s SATPUDA PAPER MILLS:

- **Evaporators:**

Five effects Long Tube Vertical Evaporators followed by two numbers Forced Circulation Evaporators for a water evaporation of **24 tonnes per hour** with heating surfaces of 245, 245, 295, 295, 295 square meters for MEE and 65, 65 square meters for FCE were supplied with a steam economy of 4.2 while five effects in operation.

- **Recovery Boiler:**

As against the 12 **kgs/cm²** pressure specified by the paper mills the boiler was designed for **22 kgs/cm²** to facilitate operating the soot blowers at **16 to 18** kgs/cm². At this pressure range, the soot blowers are very effective. **Top suspended Bi-drum boiler with tower furnace** and liberal cross sectional area with **platen screens, wide spaced** convection tubes, provision for furture economiser, **Membrane** wall construction, **decanting** hearth, **three tier** air system, air regulation arrangement for **individual air ports, cylonic tertiary** air system designed for high turbulance three numbers **rotary retractable** soot blowers operated by steam, three numbers **sonic** soot blowers operated by air, four numbers liquor spray guns with steam atomisation, two of the guns having **oscillating mechanisms,** all four spray guns operable in **stationary** mode with variable angle firing into furnace; centrifugal pumps for feeding liquor to spray guns; **Cyclone Evaporator** as direct contact Evaporator; **Ventury scrubber** for **secondary recovery** of chemicals from the flue gases, **two induced draft fans** one after the cyclone evaporator and another after the ventury scrubber with **facility for isolation** and operating independently as needed; **mixing tank** for operating the system on kraft process if required with the addition of salt cake preperation and feeding system; dissolver; Oil burners specially designed for low output and high output operations; facility for using the **oil burner in the primary ports** for melting the smelt **at the spout area,** etc., were supplied.

Causticisers:

In view of uncertainity with lime purity, the causticisers were designed for lower purity, (40% for short durations & 50% for longer durations against 60% specified by Satpuda) Big capacity rotary **drum slaker,** Big capacity **rake classifier,** three **causticisers** in series, **Single-tray clarifiers** for the **white liquor** clarification, **primary** and **secondary mud washing, vacuum filter** for the final stage mud washing, **green liquor clarifier with dregs washing system, lime handling** system with all other accessaries and the auxiliaries were provided.

ACTUAL PLANT PERFORMANCE FROM APRIL 95 TO MARCH 97:

The yearly abstracts of CRS performance for 1995-1997 are given in **Table-1**. It may be noted that all the essential data for the CRS plant analysis are covered and given in a format which is very easy to understand.

Table-2 gives the **Steam consumption** at various points and **Table-3** gives the direct cost of Recovered caustic. Table-1,2,3 are annexed at the end of the article.

From the data in **Table-1,** various analysis can be made, such as yield, BLS, concentration, water evaporation, steam economy, steam per Tonne of BLS, caustic Recovered, Soda Recovery efficiency, lime required etc.

One of the analysis could be with regards to the plant utilization and it is as follows:

During April 95-March 96 the Actual plant was in operation for about **50%** of the time. During the operational period, the plant was operated at about **85%** of the rated capacity and the overall plant utilization for the year was about 50%.

During April 96-March 97 the actual plant was in operation for about **36%** of the time. During the operational period, the plant was operated at about **83%** of the rated capacity and the overall plant utilization for the year was about **32%.**

Satpuda unit's operations were found to be **not bad** and the unit could have **behaved much better if operated at higher utilisation rate.**

Table-2 gives the **consumptions of steam at various points and generation of steam** from CRS and the net steam available/Requirement.

Summary Statement of Plant Utilization Of Satpuda CRS from April 95 to March 97.				
Details	**Units**	**Evaporator**	**Recovery Boiler**	**Causticizer**
DURING APRIL 95-MARCH 96				
Operating hours	Hrs	4249	4923	4310
Equivalent days	Days	177	205	180
Yearly Utilization Rate	%	48.5	56.2	49.3
Actual Operation Rate	t/hr and	16.06 t/hr	57.0 t/Day	14.89 t/Day
	t/Day	Water evp..	(Dry BLS)	(TAA white liquor)
	%	66.9	87.7	114.5
Overall Utilization Percentage	**%**	**32.4**	**49.3**	**56.4**
DURING APRIL 96-MARCH 97				
Operating hours	Hrs	3541.5	3128.5	2783.5
Equivalent days	Days	147.5	130.4	157.6
Yearly Utilization Rate	%	40.4	35.7	43.2
Actual Operation Rate	t/hr and	13.44 t/h	53.9 t/Day	12.55 t/Day
	t/Day	(Water evap..)	(Dry BLS)	(TAA white liquor)
	%	56.0	82.9	96.5
Overall Utilization Percentage	**%**	**22.6**	**29.6**	**41.7**

TABLE-1

SATPUDA PAPER MILLS-YEARLY ABSTRACTS OF CRS PERFORMANCE (FOR 1995-1997)

			APR. 95 - MAR. 96			APR. 96 - MAR. 97		
S.No.	**Description**	**Units**	**Total**	**Per Tonne of UBP**	**Per Day***	**Total**	**Per Tonne of UBP**	**Per Day***
A:	**GENERAL MILL PERFORMANCE:**							
1	Paper Production	Tonnes	11485	1.09	64.4	7255	1.14	55.1
2	Un Bleached Pulp production.	Tonnes	10547	1.00	59.1	6372	1.00	48.4
3	Bleached Pulp	Tonnes	9892	0.94	55.5	5978	0.94	45.4
4	Raw Material Consumption (@ 50% moisture).	Tonnes	46000	4.36	258.0	30000	4.71	227.7
5	BD Raw Material	Tonnes	23000	2.18	129.0	15000	2.35	113.8
B:	**CRS PERFORMANCE :**							
1	Black Liquor Received	Cu.m	89102	8.45	499.7	57307	8.99	434.9
		°TW	8.0		8.0	8.0		8.0
2	Black Liquor Processed	Cu.m	88991	8.44	502.7	60105	9.43	407.3
3	SCBL Produced	Cu.m	20771	1.97	117.3	12523	1.97	84.9
		°TW	45		45.0	45		45.0
4	Water Evaporation	Tonnes	68220	6.47	385.3	47582	7.47	322.5
		t/hr	16.06			13.44		

			APR. 95 - MAR. 96			APR. 96 - MAR. 97		
S.No.	Description	Units	Total	Per Tonne of UBP	Per Day*	Total	Per Tonne of UBP	Per Day*
5	Steam Consumed In Evaporators.	Tonnes	16242.9	1.54	91.7	11329.0	1.78	76.8
6	SCBL Fired	Cu.m	20813	1.97	101.5	12585	1.98	96.5
7	BL Solids Fired	Tonnes	11698	1.11	57.0	7023	1.10	53.9
8	Fuel Oil Fired	KL	300.1	0.03	1.46	182.2	0.03	1.4
9	Steam Generated	Tonnes	26421	2.51	128.8	15862	2.49	121.7
10	Total Alkali To Digester							
	TTA as NaOH	Tonnes	4156.5	0.39	23.3	2544.7	0.40	19.3
	TAA as NaOH @ 100/120 Causticity	Tonnes	3463.8	0.33	19.4	2120.3	0.33	16.1
11	TTA Produced as NaOH	Tonnes	3209.3	0.30	17.9	1747.3	0.27	15.1
12	Caustic Produced	Tonnes	2674.4	0.25	14.9	1456.1	0.23	12.6
13	Makeup Caustic in Digester as NaOH	Tonnes	1130.9	0.11	6.3	817.5	0.13	6.2
14	Lime Consumption In Causticizing.	Tonnes	3788	0.36	21.1	1758	0.28	15.2
15	Recovery Efficiency	%	74.0		74.0	74		74
16	Plant Running Hours:							
	Evaporators	hrs	4249.0			3541.5		
	Recovery Boiler	hrs	4923.0			3128.5		
	Causticizing	hrs	4310.0			2783.5		
17	Opening Stock Of Alkali	Tonnes	107.8			118.7		
18	Closing Stock of Alkali	Tonnes	118.7			113.0		
C:	**SUMMARY :**							
1	Average Daily Paper Production for the year.	Tonnes		1.09	31.4		1.14	19.9
	- % of The Rated Capacity @ 65 TPD M/c Production.				48.3			30.6
2	Average Daily Unbleached Production for the Year.	Tonnes		1.00	28.8		1.00	17.5
	- % of The Rated Capacity @ 50 TPD Bleached Pulp.				54.1			32.7
3	Average Daily DBLS Fired.	Tonnes		1.11	32.0		1.10	19.2
	- % Rated Capacity @ 65 DBLS Firing.				49.2			29.6

* **For Pulp Mill & Paper M/c running hours considered average running hours of Evaporators & Causticizers.**

Note: No Furnace Oil is Required while in Operation.

The Plant was interrupted constantly & Furnace Oil was used Startup & Shutdowns.

TABLE-2

SATPUDA PAPER MILLS-STEAM CONSUMPTION & GENERATION

LEGEND :	Pressure	Temp.	Enthalpy
	Kgs/Cm²	Deg.C	Koala/Kg
	LP : 3.50	Sat.	654.85
	MP : 10.5	Sat.	664.10
	HP : 20.0	Sat.	668.20

		APR. 95 - MAR. 96			APR. 96 - MAR. 97		
S.No.	**Description**	**Quantity in Tonnes**	**Cat.**	**Equi. MP Steam Tonnes**	**Quantity in Tonnes**	**Cat.**	**Equi. MP Steam Tonnes**
A:	**EVAPORATORS:**						
1	Water Evaporation	16243	LP	**16017**	11329	LP	**11171**
2	Steam Ejectors	2974	MP	**2974**	2479	MP	**2479**
	Total			**18991**			**13650**
B:	**RECOVERY BOILER:**						
1	Air Heating	3492	MP	**3492**	2097	MP	**2097**
2	Black Liquor Heating	838	MP	**838**	503	MP	**503**
3	Smelt Shattering	492	MP	**492**	313	MP	**313**
4	BL Spray Guns	251	MP	**251**	151	MP	**151**
5	Oil Burner Atomization	52	MP	**52**	33	MP	**33**
6	Soot Blowers	57	MP	**57**	36	MP	**36**
	Total			**5182**			**3133**
C:	**CAUSTICIZERS:**						
1	GL Heating	491	LP	**484**	267.0	LP	**263**
	Total			**484**			**263**
	TOTAL FOR CRS :			**24657**			**17046**
D:	**STEAM GENERATION @ 18.0 Kgs/Cm² (g), Sat. Temp./ with 667.7 Kcal/Kg Enthalpy.**	26421.0	HP	**26564**	15862.1	HP	**15948**
E:	**NET ADDITIONAL STEAM**			**-1907**			**1098**

TABLE-3

SATPUDA PAPER MILLS - COST OF RECOVERED CAUSTIC BASED ON ACTUAL PERFORMANCE (FOR 1995-1997)

S.No.	Description		APR. 95 - Mar.96 Total	APR. 96 - MAR. 97 Total
	INPUTS :			
1	Net Steam Consumption	Tonnes	-1907	1098
2	Power Consumed			
	Evaporators	kWH	132569	110495
	Recovery Boiler	kWH	984600	625700
	Causticizing	kWH	254290	164227
	Total	kWH	1371459	900421
3	Fuel Oil Fired	KL	300	182
4	Lime	Tonnes	3788	1758
	OUTPUTS :			
1	Caustic Produced	Tonnes	2674	1456

	DIRECT COST OF RECOVERED CAUSTIC	Rate Rs.	Quantity	Cost Rs. Lakhs	Cost/Tonne of Caustic Rs.	Quantity	Cost Rs. Lakhs	Cost/Tonne of Caustic Rs.
1	Net Steam, Tonnes	450.0	-1907	-8.58	321	1098	4.94	**339**
2	Power, kWH	3.75	1371459	51.43	1923	900421	33.77	**2319**
3	Furnace Oil, KL	7767.0	300	23.30	871	182	14.14	**971**
4	Lime, Tonnes	2250.0	3788	85.23	3187	1758	39.56	**2717**
	Total Cost			**168.54**	**6302**		**92.41**	**6346**

Table-3 deals with various **inputs and outputs** from which the **direct cost** of recovered caustic is arrived at. Here the **steam cost** is taken as Rs. **450** per tonne and **power cost at Rs. 3.75 per KWH** but this may differ from unit to unit.

COST OF RECOVERED CAUSTIC

Caustic produced as NaOH for 95-96 and 96-97 respectively were 2674.4 and 1456.1 Tonnes.

S. No.	Item	Cost/Tonne of Caustic (Rs.)	
		Apr. 95 - Mar. 96	Apr. 96 - Mar. 97
1	Power	1923	2319
2	Net steam	-321	339
3	Furnace Oil	-871	971
4	Lime	3187	2717
	Total	6302	6346

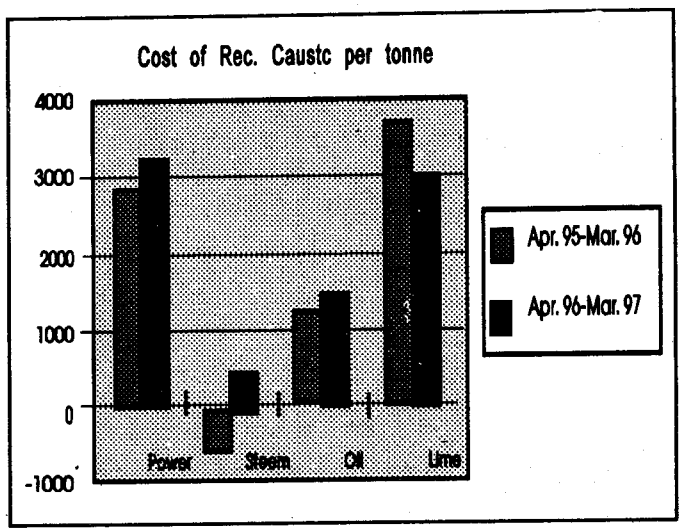
Inspite of adverse conditions, the direct cost of Recovered caustic per Tonne, for the year **Apr 95 to Mar 96** came to **Rs. 6302** and for the year **Apr 96 to Mar 97** came to Rs. **6346.**

In view of small basic capacity of the CRS unit and in view of unavoidable low overall utilisation of the plant, it is **advisable to reduce the investment cost intially.** Some of the points could be

1. To Consider SS tubes in evaporators at a future date.
2. To Consider cyclone evaporator with centrifugal pumps if possible.
3. To Consider Electrostatic precipitator at a future date.
4. To have most essential instruments only in the first stage.

Certain Important Events & Dates Of Occurrence While executing

1	Issue of letter of intent	March 08, 1990
2	Signing the contract	June 21, 1990
3	Completion of Recovery Boiler Erection & Clearance by IBR authorities (Hydraulic Test)	September 17, 1993



4	Due to the non availability of trained Operational personnel, in-house training programme was taken up.	Sept.. to Oct, 1993
5	In-situ Dynamic Balancing of ID1 & ID2 fans	September 15, 1993
6	Chemical cleaning of Boiler	October 27, 1993
7	Feed water tank job completion by Satpuda & supply of Boiler feed water	November 10, 1993
8	Oil firing	November 10, 1993

9	Mr. SN. SINGH Joined paper mills as incharge Soda Recovery.	November 11, 1993
10	Evaporators startup	November 11, 1993
11	Safety valve setting	November 12, 1993
12	Non availability of Steam to Evaporators due to problem with the Coal Fired Boiler (Tube failure)	November 13 to 17, 1993
13	Trials with Black liquor & Replacement of Black liquor spray guns by Steam Atomized guns.	November 17, 1993
14	Black liquor firing	November 18, 1993
15	Cyclone evaporator motor failure	November 19, 1993
16	Dissolver agitator replacement by a jet agitator.	November 19, 1993
17	Restart up of Recovery Boiler	November 21, 1993
18	ID1 fan failure	November 23, 1993
19	Arranged bypassing of ID1 fan and taking ID2 fan into circuit.	November 26, 1993
20	Minor accident in the cyclone evaporator	November 28, 1993
21	Commencement of Operation of furnace with lower concentration of Black liquor (From 59% to 54%)	November 28, 1993
22	Causticisers startup	December 03, 1993
23	Problem with scalloped bars supporting the refractory in the Furnace.	January 25, 1994
24	Restart up of Boiler after modifications to the Refractory work supproting system	February 07, 1994
25	ID2 fan failure	May 30, 1994
26	Restart up of the plant	June 03, 1994
27	Completion of performance guarantee trials.	August 24, 1994

Like in any new project, CRS start up at Satpuda had some teething problems. Some of them are briefly discussed here below:

● **First problem : Non availability of Trained hands:** The hydraulic test for the boiler was conducted and IBR clearance was obtained on **September 17, 1993.** At this juncture also, **no trained operating personnel could be recruited** by Satpuda for operating the plant. The reasons were as follows: While there are **350** paper mills, Recovery units are confined only to about 30 Big mills. The people from these big mills were generally **not willing to join the small mills.** The salary as demanded by those willing to join was very high compared, to the salaries as prevailing in the **Sugar units.** The salary demanded for the post of the Manager Soda Recovery was more than the salary drawn by the MD of the unit. **The salary as demanded by the operators in general was more than the salary given to the Senior people working in the sugar mill** and its ancillaries. This posed a serious problem, since the paper and pulp units were ready for start up. Ultimately it was decided to go ahead with

the in-house training programme while keeping the search for operating personnel on. TMT took up the training programme. The local candidates were recruited and the training was imparted to them in a systematic fashion. Modular programmes were prepared and individuals were trained for the **routine** aswell for the **emergency operations.** Many **job simplification steps** were also taken up **to cope up with the skills of new hands** such as:

1. Safe operation of the Boiler during emergencies:

Automatic feed water control was already available in the plant along with the high and low water alarms and a recorder, Hence no problem is expected in the normal operation, however it is essential to safe guard the unit when the unit is operated in emergencies with out the feed water regulator. For this, the operator should have the correct indication of the water level in the Boiler drum. Arrangements were made to see the Bicolour gauge glass from the feed water control valve, one IGEMA remote level indicator was also installed near feed water valve. A board with electrical bulbs was provided for getting the indications of boiler water level operated by a person kept at the Boiler drum. This light system however was for using when all the other facilities fail and also during the startup. When the Boiler is in operation the blow down valves need to be operated. When ever blow down is given, it is essential to know the boiler level correctly. Hence the Boiler blow down valve was installed near the operator's station so that blow down can be given looking at the Remote level indicator or Bi-colour gauge glass or the level indication in the Recorder.

2. Proper Operation of oil Burners :

Regulation of oil pressure to the Burners is based on the furnace condition which changes constantly. For the accurate oil pressure regulation, needle valves on the return line of oil, and a needle valve on the atomising steam line were provided along with the local mounted pressure gauges. They were installed very close to the burners and were easily accessible to the operators.

The oil flow in the individual oil burners at Satpuda were found to be as follows :

Rate of oil firing for the oil burner (oil Temperature 110°C)		
Oil Pressure Kgs/cm²	Oil flow l/Hour	Corresponding Steam Pressure
2.0	60	3.5
2.66	100	4.0
3.50	140	5.0
4.25	180	5.7
4.66	200	6.2
Atomising Steam Pressure to be kept 1.5 Kgs/ cm² more than the oil pressure.		

3. Proper Operation of three tier air system :

Three tier air regulation is a vital aspect and the Standards as adopted by Babcock Wilcox, & Combustion Engineering are compared with TMT,s design for Satpuda and is given here below:

Supplier	Pressure at ports as mm WC			Air flow %		
	P	S	T	P	S	T
B & W	75 to 100	125 to 200	125 to 300	45 to 50	20 to 35	15 to 30
CE old design	75	-	150	65 to 70	-	30 to 35
Satpuda	75	125 to 150	200 to 250	50	25	25

Legend

P = Primary

S = Secondary

T = Tertiary

The following air regulation is required for various rates of production. This is given to the Supervisors.

BLS per day Tons	Air requirement in Cu. M/sec at. 150°C with 10 % excess air			
	Total	Primary	Secondary	Tertiary
40	3.3	1.6	0.85	0.85
50	4.0	2.0	1.0	1.0
60	4.9	2.4	1.25	1.25
65	5.3	2.6	1.35	1.35
70	5.7	2.8	1.45	1.45
75	6.1	3.0	1.55	1.55

Where as the operators were provided with the following display Board.

BLS /day Tons	SCBL Cu.M/H	DP to be maintained on U-Tube Manometers located at Respective stations in mm WC.			
		FD	PRIMARY	SECONDARY	TERTIARY
40	3.7	28	39	18	28
50	4.6	44	61	28	43
60	5.6	63	88	41	63
65	6.0	73	103	47	73
70	6.5	86	120	55	86
75	7.0	98	137	63	98

When ever burners are in use the air requirement also to be corrected and equivalent air for BLS firing is given for giving the additional air.

Oil flow Cu.m /h	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Eqt. To BLS/day	5	11	16	21	27	32	37	43	48	53

4. Dissolver level regulation & green liquor control :

The manual regulating valves on the delivery line of the green liquor pumps for the level control along with mechanical indicator for the dissolver level were provided near the spout operator. The weak white liquor addition for the density control along with local density indication, by the twaddle meter were installed near the spout operator. This is in addition to the instrumentation system provided for operating the system even when instruments fail.

5. Liquor distribution into furnance :

For the tiny capacity of Satpuda unit even one gun is more than sufficient to fire the liquor into furnace. However, when one gun is used equitable distribution of liquor into the furnace was becoming difficult. Hence four guns were provided and they are operated at the same pressure, and the pressure is regulated by throttling the valve on the return line of the liquor. The guns were converted to stationary mode and directed at an angle into furnace for uniform distribution of liquor into the furnace.

6. Emergency Shut down system as perBLRBAC recommendation :

The night mare in a smelting type Recovery Boiler is the possibility of explosion due to smelt water reaction. While all steps are to be taken to avoide smelt and water to come in contact, the unit should have facilities for immediate shutdown of the system and to drain the water in the boiler while attending to various other operations as per BLRBAC recommendations. The system was designed and the facilities were provided for manual operation. The emergency blow down valves located with easy accessibility by operators. The supervisors, operators and maintenance crew were trained to carry out emergency shutdown operation. The display board with sequential operation was kept at operators point.

- **The second problem encountered during startup was non availability of Boiler feed water to CRS.** The Boiler feed water pump was originally planned to be in the Coal fired Boiler area which was away by about 150 meters. Subsequently it was decided to shift the boiler feed water pump to the CRS unit. This arrangement needed a new feed water tank. Hence there was a delay of about 1 month for commissioning the Recovery Boiler.

- Between **13 to 17 th November 1993 the failure of coal fired boiler** delayed the start up of evaporators & Soda Recovery unit by four days.

- On **18th November 1993** when the unit was started, the viscosity of the Black liquor posed problems. The liquor was **not getting atomised** and falling as a jet into the furnace. TMT installed a new type of spray gun with steam atomization facility. This gave excellent results.

- Soon after the startup of CRS on **19th November 1993** the main **Dissolver agitator** developed problems. A **jet agitator** was developed and installed with in a day.

- On **November 21, 1993** the unit was **restarted.** After two days smooth operation of the unit, **ID 1 fan** gave problems on 23 November 1993. In the night shift, the viscosity of the liquor went up causing jamming of the liquor circulation nozzles. The cyclone evaporator exhaust flue gas temperature shot up. In a routine fashion when steam Lancing and hot water lancing to the ID fan was taken up, the impeller got distorted causing vibrations. The fan was rebalanced and the unit was kept in operation. **On 28th, November 93** there was a **minor fire accident** in the Cyclone evaporator due to nozzle jamming. These would not have happened were if experienced operators available in the plant. Where as, there was not even a single experienced operator and still the plant was to be kept in operation and plant safety also to be ensured. In view of these problems, it was decided to operate the Recovery unit at 54% concentration instead of 59% concentration. At 54% concentration the viscosity problems was relatively lower, especially when higher RAA was maintained with alkali addition into liquor. This helped

in avoiding problems with pumps and nozzles of cyclone evaporator. Requirement of operator skill and attention were reduced to a great extent.

- On **25 January 1994,** the scallop bars supporting the refractory of the furnace caused problems. The unit was taken out of circuit and the complete supporting system was reworked.

- The unit was started on **7 February 1994.**

- **The unit operated without problems during the months February, March, April, may 1994.**

- While in operation **on 30 May 1994 ID2 fan gave way** due to some foreign matter comin into the fan and causing damage to impelle vanes. Arrangements were made to make a modified impeller with Radial vanes. Radial vanes were provided to avoid chemical deposits. The speed of fan was reduced, to decrease the fan capacity in line with actual requirement. The original fan was having unused capacity margin. With this the power consumption could be reduced.

- On **June 3, 1994** the unit was restarted by taking **ID 1 fan** into circuit. Having two ID fans improved the flexibility and avoided costly shutdowns.

- The plant operated satisfactorily during the months **June, July, August 1994.**

- Guarantee trials were conducted between **August 17 to 24, 1994.** The trials were satisfactory. The plant performance was found to be better than the guarantees specified in the contract. The furnace was found to be stable from **60% capacity to 120%.** At **120%** capacity operation, there was no abnormal increase in back end temperature indicating the scope for firing more liquor. Beyond **120%** capacity the **ID fan** was the bottle neck since the fan capacity, was reduced to save power. It was concluded that the fan capacity may be increased in furure if higher capacity operation is needed.

The experiences were very interesting, challenging, educating and the interruptions to the operation were too few lasting for short durations. Most of the problems were with auxiliaries but not related to the pressure parts of the boiler.

Operating experiences & changes to some original plans :

While Commissioning certain changes to the original plans were made. Some of them are mentioned here below along with the operating experiences:-

● Evaporators: Operated 5 effects without FCE & without water Boiling:

According to the contract, 4 effects evaporators are to be kept in operation with one effect as standby to facilitate regular tube cleaning to one effect to dislodge seals caused by bad black liquor. Where as, Satpuda was having a good wet depithing system associated, and good quality black liquor could be obtained. The viscosity problem with soda bagasse liquor was successfully tackled by maintaining high RAA, about 12 to 15 gpl, by the addition of white liquor caustic in the Black liquor storage tank, in the evaporators and in the Cyclone evaporator. Big size causticisers at Satpuda facilitated in clear white liquor without much lime carryover. Hence, the stand by effect also was taken into circuit to give better steam economy.

Originally it was planned to have regular water boiling in the evaporators. In view of lower capacity operation and liberal heating surfaces provided in evaporators, the fall in capacity on daily basis was not significant and no water boiling was carried out on regular basis.

Initially, scaling problems were experienced in the evaporator tubes. Satpuda procured a hydra dynamic pump for the cleaning of the evaporator tubes. This gave good results. At present, the frequency of tube cleaning is around two months. The scales are present in 1st, 2nd and 3rd effects tubes.

In view of high viscosity problem assosiated with of soda black liquor, Forced Circulation Evaporators were installed to function as a fall back device to get the desired 45% concentration of the liquor

from evaporators. However with regular control of RAA the 45% concentration could be achieved in MEE it self. Hence FCE operation was discontinued. Since it consumes higher power.

●ID fans capacity reduced in line with process requirement to save power & Radial vanes were provided to reduce deposits

According to the standard practice, the fans are to be designed for 30% higher capacity and 30% higher head and the power consumption would be almost double the power requirement at the operating capacity. To save the power, ID 2 fan was operated at a lower speed. Radial vanes were also provided to the new impeller to reduce chemical deposits on the impeller which causes vibration.

●Black liquor spray guns:

Proper distribution of black liquor into the furnace and maintaining the proper droplet sizes from the spray guns into the furnace is essential to avoid ledge formation, to avoid chemical deposits in the Boiler passes, to avoid blackening & smelting of air ports etc.

Initially the trials were made with oscillating spray guns fitted with nozzles having mechanical atomisers. After various trials, resorted to stationary mode with steam atomised spray guns. Even though one gun is ample to meet the capacity requirement four spray guns were used to have even distribusion of liquor into furnace hearth. Proper regulation of char-bed resulted in the smooth operation of air ports and smooth discharge of smelt from the furnace and the spout. The Soda liquor melting point is higher than that of the Kraft liquor which should theoretically cause more problems in the spout area. But they were not faced due to the afore said reasons.

- **The soot blowers were not operated:** Three numbers **rotary retractable steam operated soot blowers** were provided for the **furnace zone** and three numbers **sonic** soot blowers were provided for the **convection zone.** Since there were no deposits any where in the Boiler the soot blowers were not operated at all. The three sonic soot blowers were disconnected, However, of late, the rotary retractable soot blowers are operated once a shift in 15 days as against three shifts' operations every day. This is done as a ritual.

- **Liquor flow meters gave problem: JN Marshall's** magnetic flow meters were provided for measuring black liquor but the instruments gave problems and the flow could not be measured. Two SCBL tanks were available in the plant. One tank was for receiving the liquor and another for consumption of the liquor. The tanks were changed once in 8 hours.

- **The Draught gauges supplied by H-Guru gave problems.** U-tube manometers were installed which were found to be more reliable and free from problems.

- **During normal operation no auxiliary oil support is needed for the operation of furnace.** The furnace is stable even with partial loads. The furnace oil consumption for the startup from cold condition is also very low and is about 400 liters.

- **To reduce the losses at the rake classifier,** some modifications were carried out to the rake classifier.

TMT has been advising Satpuda to carry some more modifications to improve the operation of the unit further and to reduce the cost of recovered caustic. They are as follows:-

1. Addition of one or two effects evaporators.
2. Modifications to brown stock washers to give higher concentration liquor.
3. Using vacuum pump instead of steam ejectors in evaporator.
4. Modifications to blow heat recovery system to use heat for white liquor heating and using the hot water from continuous Digester in the evaporator section...

TMT was advocating for higher pressure boiler during initial stage of project to facilitate power generation. However this could not be considered at

that time. However, in the case of a new project the advantage of power generation by high pressure super heated steam may be considered.

The financial benefits by carrying out some of the improvements would be approximately as follows:

1.By increasing concentration of Black Liquor to 11% in washing stage.	Reduction in the water evaporation: 5.47 t/hr; Reduction in steam requirement (considering 5 effect @ 4.2 steam economy): 31.27 t/Day Saving in operational cost per day Rs. 14,069; Saving in Cost/tonne of recovered caustic: Rs. 1082.
2.By increasing the 5 effect evaporators to 7 effect evaporators the steam requirement can be reduced.	Reduction in the steam requirement (considering 5 effect @ 4.2 & 7 effect @ 6.0 steam economy): 41.26 t/Day. However there will be increase in power consumption about 825.6 kWH/Day. The overall saving in operational cost per day Rs. 15,472, Saving in cost/Tonne of recovered caustic: Rs. 1,190.
3.Installation of Electro Static Precipitator in place of the Venturi Scrubber.	Reduction in power consumption: 2040 KWH/Day Saving in operational cost per day Rs. 7,650, saving in cost/ Tonne of recovered caustic: Rs. 588.
4.Using vacuum pump instead of steam Ejectors.	Reduction in steam requirement: 16.80 t/Day, Increase in power consumption: 576 kWH/Day saving in operational cost per day Rs. 5,408, Saving in cost/Tonne of recovered caustic: Rs. 416.

5.Power Generation:

Generating steam @ 42 kgs/cm² & 410°C & passing through a back pressure turbine with a back pressure of 3.5 kgs/cm².	Equivalent steam generation: 6.49 t/hr @ 42 kgs/cm² & 410°C, 7.65 t/hr @ 3.5 kgs/cm² & Sat. Temp. Power produced: 645 kWH/HR, 15,576 kWH/Day Steam to process: 163.20 t/Day, Equivalent reduction in steam generation: 20.40 t/Day saving in operational cost per day Rs. 49,205, saving in cost/Tonne of recovered caustic: Rs. 3,785.
If the power generation is from 42 kgs/cm², and 420°C to 10 kgs/cm² and not from 42 kgs/cm² & 410°C to 3.5 kgs/cm² the power generation comes down.	Considering 42 kgs/cm² & 410°C steam extracted at 10.5 kgs/cm², the power produced would be around 519 KWH/Hr, Saving in cost/Tonne of Recovered caustic would be around Rs.3035/-.
In the pulp plant & Recovery section 10 kgs/cm² steam is required by the digesters, ejectors, Air heater, oil burners, Black liquor heating, smelt shattering etc. The quantity is approximately equal to that of the steam generated from Recovery Boiler.	**Hence power generation from 42 kgs/cm² to 3.5 kgs/cm² is of academic importance. Further, in the case of pulp mills with Batch digesters the steam demand fluctuates, and the power generation also fluctuates unless the turbine is parallelled with grid. Small mills have to study their options & have to decide carefully.**
6.By pumping the excess foul condensate from CRS to Brown stock washers.	The excess foul condensate available from CRS for Brown stock washers is about 328 Cu. M/Day @ 60°C equivalent to 19.40 Tonnes of LP steam that is equivalent to a Saving of Rs. 8730 per Day.

However there will be power consumption about 52.8 kWH per Day equivalent to Rs. 198.

Net saving: Rs. 8,928.

Saving in Cost/tonne of recovered caustic is Rs. 687.

Since **Blow heat Recov ery water it self is in excess,** this scheme is feasible only after proper use of Blow heat for white liquor heating & utilising flash heat in evaporators. The savings by such a scheme is quite significant.

Development of Recovery System for Straw liquor

CRS for bagasse is now real and is acceptable to mini mills using bagasse as raw material. But there are many mills using Straw as raw material. Now it is essential to have a unit which can meet the challenges of straw liquor.

TMT's plans in this regard are briefed here under:

Some problems encountered with straw liquor & Chemical Recovery units compared with Bagasse system are as follows.

- Size of the CRS units are smaller
- Chemical requirement for pulping is lower.
- Washing of pulp is more difficult and the Black liquor to evaporator will be more dilute.
- Silica content is high in Straw liquor, More problems are expected in evaporators and furnace.
- More foreign matter exists in the straw liquor.
- Calorific value is lower.
- Viscosity of Black liquor at higher concentration is higher than that of Bagasse liquor.
- The technology should be simple enough in line with skills available with the small sized paper mills to operate at the same time not to compromise with the efficiencies, safety standards.

While these are some of the problems, the options open to the mill may also be analysed.

- With depleting forest based raw materials the additional requirement of pulp for paper has to come from agricultural raw materials.

  Even if India can attain the standards of China, the scope for paper demand would be enormous and thousands of mini pulp and paper mills are required.

  The primary bottle neck to achieve this is an acceptable Chemical Recovery System.

  Hence it is essential to find an immediate solution.

- Considering the type of system or the technology to be adopted, smelting type furnace appears to be the choice. The Recovery unit for Straw liquors will be very similar to Bagasse unit with certain changes & additions.

Assuming that Satpuda CRS is used for Straw liquor the inadequacies and problems could be as Follows:

- **Considerations from evaporators point of view**
  - Straw liquor being more dilute needs bigger evaporators.
  - Silica in Black liquor can pose problems in evaporators and the scaling in evaporator tubes may be more frequent and severe.
  - In view of higher Viscosity at higher concentration,
  - The final concentration of liquor from evaporators may be lower than 45%.

Considerations from Recovery Boiler point of View:

- Silica can cause more problems in furnace and Boiler due to ledge formation and fouling of boiler passes.
- Firing of liquor at higher concentration may not be possible. This together with lower calorific value may pose real problems for the autogenous combustion. More oil may be needed.
- The blackening & smelting of air ports may be more frequent.
- Smelt discharge may not be as smooth.

The following improvements, modifications or changes may be required while using straw liquor.

W/R to evaporators:

- Evaporators capacity to be increased
- More effects are to be used to have better steam economy.
- Provide a spare evaporator for tube cleaning, Also consider chemical cleaning.
- Alternately go for falling film evaporators.
- Final concentration may be still less, Hence it is essential to reduce the viscosity, (By desilication, Depolymerisation or by other means)

W/R to Furnace :

The fouling to Boiler passes is minimum with Satpuda unit compared to any other unit available in the country. The Boiler is free from ledge formation, operates at partial loads with out auxiliary oil supports, no problem with air ports are experienced, it is operator friendly, Hence this will be the best suited unit for the purpose.

If problems are faced the soot Blowers may be used, More soot Blowers also can be considered.

Further changes to Boiler design can be taken up to over come specific problems.

If worst comes the unit may be shut once a month to clean the passes. And liquor storage capacity to be increased accordingly.

W/R to Causticisers:

Part of the silica may have to be removed in green liquor stage. Minor changes only are needed.

Before considering using Satpuda system for straw liquor the following points are to be explored. This can bring down the requirement of changes.

Raw material preperation:

This is a vital factor. A good dry cleaning system is available with CPPRI. Wet cleaning system in line with **KAH system** as adopted in Srilanka or NaCO pulping system may be considered.

These can reduce the Silica problem and improve the quality of Black liquor.

Cooking Process:

It is universally acknowledged that the silica slippage into Black liquor is greatly reduced if pH is maintained lower. Most of the silica goes with pulp and the viscosity of black liquor is also lowered. Many mills are using sodium sulphite along with caustic which reduces the pH. The overall cost of the pulp is reduced. The pulp quality is comparable if not better. Low pH liquor can be handled in CRS with caustic addition.

Hence this may be followed instead of Soda pulping. In this, Sulphur may pose problems in CRS. Technical problems are surmountable but environmental problems are to be studied. If the results are good, the Desilication unit may not be required.

NaCO pulping also is stated to be giving very encouraging results. Silica is very low, Viscosity is dramatically reduced. With NaCO liquor no problems would be encountered in evaporators and furnace. This is having a bright future. But the calorific value is reduced considerally. This appears to be the only negative factor.

Washing:

Improvement to washing is to be considered on top priority. Higher concentration Black liquor should be obtained by carrying out modifications to the existing washers or installing new washers with Belt

presses. This will reduce the investment cost of evaporators and also reduce operating cost.

Evaporators:

More effects of evaporators to be installed. Chemical cleaning techniques are to be adopted for cleaning the heating surfaces. Falling film evaporators may be good though costly.

Pre-evaporation with Blow heat Recovery Heat:

This is to be considered either seperately or along with the planning of the multiple effect evaporators.

Recovery Boiler :

The tower furnace & top suspension boiler may be the best choice technically. Smelter type furnaces with external Boilers may be considered to reduce the cost of installation.

Depolymerising unit :

If the viscosity is very high inspite of various alternatives discussed above, a thermal type of Depolymerising unit can be used. This can be added at a later stage.

Desilication unit :

If silica problem persists after the improvements suggested above, then a desilication unit may be considered. This can be added at a later stage as per requirement. Desilication units function better when silica content is higher. Even considering 80% silica removal efficiency, the residual silica should not pose any real problems in operation. The Desilication also reduces the viscosity of the liquor.

Summarising, it can be stated :

- It is possible to develope a unit.
- Consider basic unit with minimum peripheries.
- Modify or add essential items as required after field experimentation.
- Devoted supplier having exposure and knowledge of process apart from the design & supply of equipments is essential to make the project a success.
- The Chief executive of the mills should have exceptional leadership qualities to make the things to happen.

The stage is well set, and problems are not unsurmountable but still a unit should be installed and made operative to know the techno econonic feasibility. If this is successful, India can have thousands of small paper mills with straw as raw material.

CONCLUSION

The experience at Satpuda is going to be useful for the country in finding solutions for the Mini paper mills' Survival.

REFERENCES

1. "Chemical Recovery System for small Bagasse Based Paper Units, "in IPPTA Vol. 4, No.3, September 1992.
2. "Quest for Mini Recovery Systems Ends at Satpuda, " in IPPTA Conventional issue, December 1994.
3. "About the 22 Months Operational Experience of TMT's Chemical Recovery System at Satpuda," Presented in the seminar on Development of Chemical Recovery System for Small & Medium Agro Mills, Conducted on 11 September, 1995 at New Delhi By Indian Agro Mills Association.
4. "Development of Chemical Recovery System for Agro based raw material by TMT (INDIA) LIMITED," presented in the Seminar conducted by Indian Institute of Chemical Engineers, Hyderabad in February , 1996.
5. "TMT's Approach for Chemical Recovery System for Agro based units in India," presented in the seminar conducted by Indian Agro Mills Association at Hyderabad.
6. "Development of Chemical Recovery System for Cleaner Production in Mini Agro based Pulp & Paper Units," presented in the Workshop on "cleaner Production in Pulp & Paper Mills", organised by Central Pollution Board (CPCB) at Hyderabad on 29-30 April, 1997.
7. "Presentation On CRS," in UNEP report No. 43.

PROJECT : SATPUDA
AREA : CHEMICAL RECOVERY SYSTEM
DOCUMENT : DETAILS OF STEAM REQUIREMENT/ Supp. Data & Calculations

S.NO.	DESCRIPTION	UNITS	VALUES	
			Apr.95-Mar.96	Apr.96-Mar.97
1.00	**STEAM CONSUMPTION IN EVAPORATORS:**			
1.01	For Water Evaporation In Evaporators			
	- WBL Processed	Cu.m	88991.0	60105.0
	- SCBL Produced	Cu.m	20771.0	12523.0
	- Water Evaporation	Tonnes	68220.0	47582.0
	- Steam Economy (Considering Steam Economy of Performance Trials.)	No.	4.2	4.2
	- LP Steam Consumption For The Year	**Tonnes**	**16243.0**	**11329.0**
1.02	For Vacuum Creating System			
	- Evaporators Running Hours (Actual)	hrs.	4249.0	3541.5
	- Hourly Rate Of Steam Consumption For Ejectors (Calculated based on Pressure Drop, estimated.)	t/hr	0.7	0.7
	- MP Steam Consumption for The Year	**Tonnes**	**2974.0**	**2479.0**
2.00	**STEAM CONSUMPTION IN RECOVERY BOILER :**			
2.01	For Air Heating :			
	- Black Liquor Solids Fired	Tonnes	11698.0	7023.0
	- Air Requirement @ 5.5 t/t Of BLS	Tonnes	64339.0	38626.5
	- Air Inlet Temperature	Deg.C	30.0	30.0
	- Air Outlet Temperature	Deg.C	160.0	160.0
	- Air Specific Heat	K.Cal/Kg-^{0}C	0.2	0.2
	- Heat Absorbed By Air Heater	M.Cal	1672814.0	1004289.0
	- Heat Value Of Steam @ 10.5 Kgs/Cm^2	K.Cal.Kg	479.0	479.0
	- MP Steam Consumption for The Year	**Tonnes**	**3492.0**	**2097.0**

S.NO.	DESCRIPTION	UNITS	VALUES	
			Apr.95-Mar.96	Apr.96-Mar.97
2.02	For Black Liquor Heating			
	- Black Liquor Solids Fired	Tonnes	11698.0	7023.0
	- CBL Concentration	%	54.0	54.0
	- CBL Quantity	Tonnes	21663.0	13005.6
	- CBL Specific Heat	K.Cal/Kg-Deg.C	0.6	0.6
	- CBL Iinle Temperature	Deg.C	90.0	90.0
	- CBL Raised temperature	Deg.C	120.0	120.0
	- MP Steam Total Heat	K.Cal/Kg	479.0	479.(
	- MP Steam Consumption for The Year	**Tonnes**	**838.0**	**503.0**
2.03	For Smelt Shattering			
	- Nozzle Size	mm x mm	15.0	15.0
	- Differential Pressure	Kgs/Cm^2 (g)	9.5	9.5
	- Steam Specific Weight	Kgs/Cu.m	5.9	5.9
	- Equivalent Head	mLC	16156.0	16156.0
	- Steam Velocity @ 0.5 Orifice Coefficient	m/Sec	282.0	282.0
	- Max. Volumetric Flow	Cu.m/hr.	15.2	15.2
	- Steam Specific Volume	Cu.m/KG	0.2	0.2
	- Steam Quantity	t/hr.	0.1	0.1
	- Recovery Boiler Running Hours (Actual)	hrs.	4923.0	3128.5
	- MP Steam Consumption for The Year	**Tonnes**	**492.0**	**313.0**
2.04	**Steam Requirement For Black Liquor Spray Guns @ 30% of the Steam to BL Heaters per The Year.**	**Tonnes**	**251.0**	**151.0**
2.05	For Oil Burners Atomization :			
	- No. Of Burners	No.	2.0	2.0
	- Oil Burner Pressure	Kgs/Cm^2 (g)	3.0	3.0
	- Steam Pressure	Kgs/Cm^2 (g)	4.0	4.0
	- Differential Pressure	Kgs/Cm^2 (g)	1.0	1.0
	- Steam Specific Weight	Kgs/Cu.m	2.6	2.6
	- Equivalent Head	mLC	3817.0	3817.0
	- Steam Velocity @ 0.5 Orifice Coefficient	m/Sec	137.0	137.0
	- Steam Side Holes	mm	1.0	1.0
	- C/s Area Of 6 Holes	m^2/1000	0.0	0.0
	- Total Volumetric Flow	Cu.m/hr	4.0	4.0
	- Recovery Boiler Running Hours (Actual)	hrs	4923.0	3128.5
	- MP Steam Consumption for The Year	**Tonnes**	**52.0**	**33.0**

S.NO.	DESCRIPTION	UNITS	VALUES	
			Apr.95-Mar.96	Apr.96-Mar.97
2.06	For Soot Blowers			
	- Steam Consumption Rate Per Soot Blowing	Kg/Min	233.3	233.3
	- Blowing Time	Min	3.0	3.0
	- No. Of Blows Per Every 15 Days	Nos	2.0	2.0
	- No. Of Days Boiler Operated	Nos	205.0	130.0
	- No. Of Soot Blowers	Nos	3.0	3.0
	- Total Blow Time per The Year	Min	246.0	156.0
	- Total HP Steam Required per The Year	**Tonnes**	**57.0**	**36.0**
3.00	**STEAM CONSUMPTION IN CAUSTICIZERS :**			
3.01	For Green Liquor Heating			
	- White Liquor Produced, TTA as NaOH	Tonnes	3209.3	1747.3
	- White Liquor Produced, TAA as NaOH @ 100/120 Causticity.	Tonnes	2674.4	1456.1
	- White Liquor Quantity	Cu.m	26744.2	14560.8
	- Green Liquor Flow @ 1.351 of WL	Cu.m	36141.0	19677.0
	- Green Liquor Specific Gravity	No	1.2	1.2
	- Green Liquor Quantity	Tonnes	43369.2	23612.4
	- Green Liquor Temperature	Deg.C	90.0	90.0
	- Green Liquor Temperature To Be Raised	Deg.C	97.0	97.0
	- Losses In Causticizers%	5.0	5.0	5.0
	- Green Liquor Specific Heat	K.Cal/Kg. Deg.C	0.8	0.8
	- Steam Pressure	Kgs/Cm^2 (g)	3.5	3.5
	- Total Heat Of Steam	K.Cal/Kg	507.9	507.9
	- Steam Consumption per The Year	**Tonnes**	**491.0**	**267.0**